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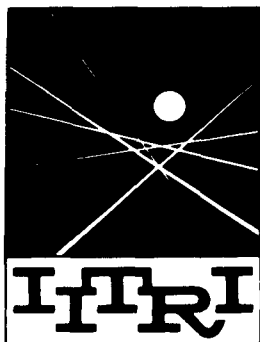


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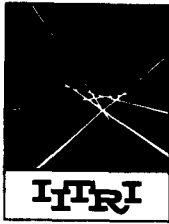
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Report No. ARF-A1203-16  
(Fifth Quarterly Report)

STUDY OF FACSIMILE SCANNING AND  
RECORDING TECHNIQUES EMPLOYING  
FIBER OPTICS

U. S. Army Signal Supply Agency  
Fort Monmouth Procurement Office  
Fort Monmouth, New Jersey

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Technology Center • 10 W. 35th Street, Chicago 16, Illinois • Area Code 312-225-9600

27 June 1963

U. S. Army Signal Supply Agency  
Fort Monmouth Procurement Office  
Fort Monmouth, New Jersey

Attention: Mr. John Erhart

Subject: Report No. ARF-A1203-16 (Fifth Quarterly Report - Final Copy)  
15 December 1962 through 15 March 1963  
"Study of Facsimile Scanning and Recording Techniques  
Employing Fiber Optics"  
ARF Project A203

Gentlemen:

## I. Introduction

This is the fifth quarterly report on Contract No. DA-36-039-SC-88927 entitled "Study of Facsimile Scanning and Recording Techniques Employing Fiber Optics" and covers the period from 15 December 1962 through 15 March 1963. The contract is concerned with the theoretical and experimental problems related to the use of cylindrical glass fibers in a facsimile scanner-recorder.

During this period, emphasis has been placed on the design and construction of equipment for the drawing of single core fiber and multiple core fiber of improved optical quality. The result of this work will be the fabrication of 50 micron diameter multiple fiber containing 5 micron diameter cores of

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uniformly high transmission. This fiber is to be used in a high resolution facsimile scanner.

## II. Experimental Results

Multiple fiber can be fabricated from glass coated glass rods varying in diameter from 0.005 to 0.015 inches. These rods are grouped into a cylindrical array and passed through a furnace wherein the coatings are fused together to provide a uniform glass matrix containing the numerous light transmitting cores. The final diameter of the individual cores and the diameter of the multiple fiber determine the size of the initial rods and the cylindrical array. For example, to form 0.020 inch diameter fiber containing 5 micron diameter cores from 0.015 inch rods requires an array of rods 1.5 inches in diameter. If the rod diameter is reduced to 0.005 inches the array diameter is proportionally reduced. At present, the smaller diameter rods are being used for experimentation because the larger rods and therefore the larger arrays require approximately nine times the volume of glass. However, multiple fiber produced from small diameter rods does not exhibit the excellent hexagonal packing obtained with the larger rods.

Defective cores are present in multiple fiber produced from small rods as well as large rods. Materials which contribute to defective fiber are glass chips introduced during the cutting of the rods, grease from physical handling of the rods and dust attracted to the statically charged rods. These foreign substances distort the multiple fiber cores or act as seeds for the formation

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of bubbles which distort the cores. A large portion of these materials have been eliminated by automatically drawing, cutting and stacking the rods in a dust free atmosphere. The static charge is dissipated by moving the rod past an ion generator. The design, construction and testing of this automatic device have been completed and rods of greater cleanliness have been drawn into multiple fiber of improved transparency. While this multiple fiber is much improved, it is not free of defects and a substantial increase in the transmission through long lengths of fiber is necessary if it is to be adequate for the present facsimile applications.

The variable transmission of the cores in the most recent multiple fiber can be attributed to defects present in the glass coated rods from which the multiple fiber is formed. Defects formed at the rod-tube interface are influenced by the manner of preparing the surfaces of the rods and tubes prior to drawing. The rods are fine ground and etched in concentrated hydrofluoric acid for a few seconds, or they are polished and further cleaned in a series of reagents such as a 10% solution of hydrofluoric acid, sodium dichromate-sulfuric acid solution, alcohol and distilled water. The tubes are supplied with reasonably smooth surfaces which may be cleaned in the same manner as the rods. Various combinations of cleaning procedures and glass materials have been tested, however, there is not a single method of preparation which has resulted in an outstanding improvement of fiber quality. Further investigation established the presence of bubbles within the bulk tubes used for the coating material. To eliminate this as a contributing factor to bubbles, selected tubes are being ordered from Corning Glass Works.

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To minimize the formation of bubbles during the drawing of rods and of multiple fiber by the entrapment of air, the volume between the rod and tube, or the rod and containing larger tube have been evacuated to a pressure of a few cm of Hg. A vacuum can be maintained because the drawing operation seals off the bottom end of the bundle. A small but reproducible improvement in multiple fiber quality was realized through this procedure.

The evacuation of open bundles of rods resulted in further improvement of fiber quality. In this procedure, the region of the bundle being fused reaches a temperature at which many materials will vaporize or burn. For foreign materials or particles to burn there must be an adequate supply of oxygen. Also, to improve the fiber quality, this burning and vaporization must occur above the region of fusion and the gaseous products must be removed before fusion. Such conditions can be created by application of a vacuum to the bundle of multiple rods which are no longer contained in an enclosed tube but are held together by wires or glass rings. The top of the multiple rod bundles at which the vacuum is applied is sealed to a glass or metal tube. As the bundle tip is sealed off the air flows through the spaces between the peripheral rods, through the interstitial spaces and is evacuated. The constant supply of oxygen to the interstitial spaces established conditions favorable to combustion. The first test of this method was performed with rods prepared by a variety of cleaning techniques all grouped into one bundle. Special precautions for cleanliness were neglected because these rods were the surplus from previous multiple fiber drawings. Multiple fiber produced

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by this vacuum technique showed a major reduction in the number of defects and excellent hexagonal packing.

Glass combinations which have been tested are: Schott F2 and Corning No. 0010, F2 and soda lime, (Demuth Glass Works), BaSF12 and 0010, SF18 and lead potash, and DBC3 and soda lime (Demuth Glass Works). The number of defective cores in fiber drawn from these combinations has varied but has never been decreased below approximately ten percent of the total fiber area. Study of the glasses suggested that multiple fiber be drawn from a combination of core and coating materials which are chemically and physically similar, and have a difference in refractive index. The glasses chosen were Corning No. 0120, Potash Soda Lead  $N=1.560$  for the core and Corning No. 0010, Potash Soda Lead  $N=1.539$  for the coating. Multiple fiber with five micron cores drawn from this combination of glasses is nearly free of defects in a two inch length. Additional tests must be performed before the success of this experiment can be fully evaluated.

The concentric crucible furnace, which will provide a broader choice of glass materials, is nearing completion. The structure for mounting and positioning the crucibles is expected to be completed within the next quarter.

### III. Future Work

During the next report period multiple fiber will be drawn from glass materials which are chemically and physically similar. These experiments will be

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aided by the completion of the crucible furnace. The polishing of the ends of the fiber scanner on pitch or diamond laps will be investigated. Equipment to photographically and photoelectrically evaluate the success of each polishing method will be designed and constructed. In this work, a simplified linear scanner will be used.

Work on this contract is recorded in ARF Logbooks C-12013, C-12014, C-12015 and C-12565. Personnel who contributed to work reported during this quarter are: A. Brushenko, C. Kot, F. X. Miller, O. H. Olson and D. A. Pontarelli.

Respectfully submitted,

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of Illinois Institute of Technology

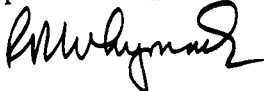


D. A. Pontarelli  
Research Physicist  
Optics Research

Approved by:



P. N. Slater  
Manager  
Optics Research



R. R. Whymark  
Assistant Director  
Physics Division

DAP/aag

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This contract is supervised by Mr. William Junkelman, Input Output Equipment Area, Data Division, Communications Department, U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey, Telephone Area Code 201 - 5351342.

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